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ACOUSTIC ABUNDANCE ESTIMATES FROM THE MULTIDISCIPLINARY SURVEY PELACUS 0401

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INTRODUCTION

The survey PELACUS 0401 was the main activity at the IEO within the frame of the PELASSES project. Main goal for this project is to try to combine different direct assessment methods, formerly acoustic and ichthyoplankton, and sampling techniques in a single research vessel in order to achieve an improvement of the abundance estimates but also a general knowledge of the ecosystem provided from extensive sampling techniques.

First idea , as stated in the scientific background of the work program, was to improve the acoustic assessment of the most important pelagic fish species in South West Europe (i.e. Atlantic waters of the Iberian Peninsula and the Bay of Biscay), specially those populations of sardine and anchovy. Major problems were identified in the acoustic procedure from the ICES Planning Group for Acoustic Surveys in VIII and IX which can be summarised as follows:

a) Problems in identifying echo-traces
b) Masking backscattering energy of fish from that of plankton organisms
c) Distribution and abundance might be related with environment conditions
d) Possible underestimation due to avoidance or near surface school behaviour

To solve that, an increase in auxiliary variables such as environmental data was needed as well as a deeper post-processing analysis, including at least two acoustic frequencies. In such sense the acoustic estimates, would greatly be improved if information from earlier development stages (mainly eggs) is gathered at the same time as the acoustic records. The recent development of the Continuous Underway Fish Egg Sampler allows to attempt combining egg and acoustic data to improve the estimation of fish abundance using the echo-integration method. CUFES, the Continuous, Underway Fish Egg Sampler, consists of a submersible pump, concentrator, electronics and sample collector (see figure 1). This system operates continuously under nearly all sea conditions, both between (10 knots) and at stations, providing a real-time estimate of the volumetric abundance of pelagic fish eggs at pump depth, 3m, with other operations able to be performed simultaneously. This pumping system consist in three elements: first, a submersible pump fixed to the ship's hull; second, a device to concentrate large particles, including fish eggs; and third, analysis devices, including a CTD, Fluorimeter, flowmeter, GPS and mechanical sampler collector. Periodically, the system's mean flow rate is measured. Concurrent with pumping, data are logged periodically from a GPS (date, time and, position), from a thermo-salinometer (and from a fluorometer (chlorophyll a - fluorescence).

In addition, the use of CUFES as egg sampler could be used as an absolute estimator of the egg abundance. The vertical distribution of epipelagic eggs can largely be explained by their buoyancy, physical conditions, and parents spawning depth. Buoyancy is estimated by measuring the ascent rate of eggs in a column. Several models have been used to describe the vertical distributions of fish eggs., could allow in the future, once CUFES was calibrated, to perform simultaneously acoustic and the DEPM methods on a single R/V and to exploit the strengths of both methods and potentially yield better estimates than are possible from either method alone. Since the surveys will be conducted at the spawning time and egg distribution can be used to improve the spatial distribution of adults. These are clearer when fish are distributed in the blind areas of the acoustic transducer (i.e. close to the sea surface or close to the sea bottom) or when avoidance reactions are strong.

Another potential application of CUFES in fisheries acoustics is the identification and fish species allocation to certain echo-traces. Fishing stations are used for echo-trace identification and fish ageing and enable to disaggregate the acoustic energy in fish density by specie and age. Since in most of the southern areas there is no possible to identify and allocate properly all the echo-traces found during a survey, different methods based in the fish species proportion found at the fishing stations have been used. Masse and Retiere (1995) applied one of them. Nevertheless, most of these methods give no information about the precision and hence, a percentage of the total variability is no measured. This source of error has been described as the poorest understood. In order to improve this knowledge, statistical methods were used and egg counts could be used as an additional explanatory variable.

According to this plan, the surveys will give an improved estimation of the abundance of pelagic fish present in the North-east Atlantic waters in spring which is the spawning period for these fish species, but focussing in sardine and anchovy. Complementary to this main objective the survey design and strategies will allow the environment be characterised by recording different variables (i.e. temperature, salinity, fluorescence, plankton, winds or air temperature) in vertical and horizontal profiles along the surveyed area with no noticeable extra-effort. As it was pointed out, these variables will help the acoustic estimations be improved whilst an extensive environment characterisation at the spawning time will be done.

Summarising, this study will provide the following outcomes:

1. A synoptic coverage from the Gulf of Cadiz to the Celtic Sea to assess by the echo-integration method the abundance of sardine and anchovy and the other pelagic fish species. This will be the first attempt to do that and this is in agreement to the ICES recommendation to cover the entire sardine distribution. New common statistical techniques will be used to improve the precision of the estimations. The results of the sardine and anchovy assessment gathered by the two methods will be compared and will be used as inputs in the analytical assessment model. For mackerel and horse mackerel, the

acoustic results will be compared with those obtained by the traditional methods (i.e. analytical assessment and Egg Production Method).

2. A map of the distribution of the main pelagic fish species at the spawning time.

3. A map of the egg distribution at 5 meters depth and, once CUFES was calibrated, egg production of the main pelagic fish species.

4. The feasibility in using a single Research vessel to obtain abundance and biomass estimates by echo-integration acoustic and daily egg production methods.

5. Biological information got at the fishing stations. There is a lack of biological information for sardine further north than 46° N. This study will provide biological samples from this area. Moreover, this information as well as the previous one might be used in future research projects to profound in the stock identity of the different fish species. This is an important feature since some of the stocks were defined in studies made long time ago.

6. Maps of climatic hydrographic and planktonic parameters that potentially influence the spatial distribution of the pelagic fish species. These maps will be coupled with maps of the different fish species within a GIS and potential relationships will be investigated using new common statistical methods.

This WD provides the main results found around the Spanish area

MATERIAL AND METHODS

The survey was carried out on board R/V Thalassa, which also undertook the French survey after the Spanish one. It covered a small area off north Portugal, the north Spanish Atlantic and Cantabrian waters and also a small area off south of France, from 31st March to 21st April.

Survey design consisted in a systematic grid with random start, normal to the coast line, with transects evenly distributed each 8 nmi, from 20 m isobath to 500-1000 m depth. Acoustic equipment consisted in a multifrequency EK-500 echosounder-echointegrator (12, 38 and 120 kHz), being calibrated during the survey those transducers of 38 and 120 kHz. The three frequencies were stored using Echoview and echograms from the 38 kHz transducer were also recorded on paper at –60 dB threshold. Acoustic data were only obtained during daytime. Fishing station for biological sampling and fish ID were provided by both trawl station, performed by the R/V Thalassa, and by seine shots performed by a chartered purse seiner. Sampling egg from CUFES were also collected each 3 nmi over the acoustic grid.

Hydrological and plankton stations were done during the night. Together with this stations, continuous records of temperature, salinity and fluormetry, which was converted to chlorophyll, were provided by a thermosalinometer and flourmeter. The stations were placed over the acoustic grid, with a inter-transect distance of 24 nmi. In each selected transect, stations were placed each 3 nmi in shallower waters, each 6 or 9 nmi in the middle of the plateau and two more station were placed at the end of the transect at a distance of 3 nmi. In each station a CTD profile until sea bottom or 250 m was done. Also a plankton haul using a 150 µm CALVET net was performed from the sea surface to the sea bottom or 100 m at deeper water. Together with this CALVET hauls, a 20 µm plankton net haul was also done. These samples were used to obtain size-fractionated plankton classes (20-40µm; 40-80µm; 80-200µm; 200-500µm; 500-1000µm) expressed in dry weight (mg m^{-3}). Samples from both CUFES and CALVET tows were sorted and anchovy and sardine egg were counted and staged. Primary production was estimated using the ^{14}C method. For this purposes a single daily station was performed at midday. Water samples were taken at different depth which were then incubated to determine P:I curves.

Acoustic data analysis

Elementary Distance Sampling Unit was fixed at 1 nmi. Fish abundance estimation was only done for the 38 kHz frequency using the Nakken and Dommasnes method. Nevertheless, echograms from 120 kHz were used to visually discriminate between fish and other scatter organism such as zoo or phytoplankton or to distinguish different fish according to the strength of the echo at different frequencies.

In order to avoid "noise" from other scatter organism threshold for integration was set at –55 dB. This threshold cut most of the plankton backscattering energy while retains most of the fish backscattering energy.

Backscattering energy was allocated into fish species using two different procedures:

a) Visual scrutiny. This method was mainly used on schools. For this purpose, the 120 kHz echogram was used as well as the results of the nearest fishing stations. In the case of sardine and anchovy, egg presence from CUFES was also used.
b) According to the fish proportion found at the fishing station. This method was mainly used on those areas where fish were seen in layers or in small schools, in a multi-specific as revealed by the fishing station. Echograms were grouped according to the similarities on echo-traces, depth and area. For each group representative fishing stations were chosen according to the number of fish species caught and the PDF of the length distribution of each fish specie. As in the previous procedure, in the case of sardine and anchovy, the presence of eggs was also used.

As well as the number of fish by length class for each fish specie, the following TS/Length relationships were used:

Specie	b_{20}
Sardine	-72.6
Anchovy	-72.6
Hake and other gadoids	-67.0
Boops boops	-67.0
Boar fish and longsnipe	-80.0
Mackerel	-82.0
Horse mackerel	-68.7
Chub mackerel	-68.7

Once backscattering energy was allocated, acoustic estimation was done over small areas. These areas (i.e. post-strata) were chosen on account both the similarity in length distributions obtained from the fishing stations (K-S test) over the surveyed area and the PDF of the acoustic energy. Then, results, either by length classes or age groups , were presented by ICES Sub-Division

RESULTS

The survey was conducted in April 2001. Figure 1 shows the survey track and figure 2 shows the location of the plankton and CTD stations. Figure 3 shows a satellite picture of chlorophyll-a concentration.

During the first two weeks (i.e. from 31^{st} March to 12^{th} April) weather conditions were bad, with deep low pressures which sent westerly winds (up to force 8-9) and rain, specially when the NW corner of the Iberian peninsula was covered. During the second part of the survey high pressures were dominant and the wind turned to N-NE component. Thus, the area was characterised by the following oceanographic features:

1. Predominance of turbulence events without thermocline
2. Haline fronts in the western part of the area, specially off north Portugal and less evident at the Rias, in Galician waters. Figure $4_{a\text{-}b}$ shows SSS and SST and fluormetry in this area
3. Coastal upwelling event in the middle of the Cantabrian coast, as shown in figure 5

In spite trawl hauls were opportunistic, but performed at different hours along the day, most of the representative fishing station for the different "echo-trace assemblages", were done at sunset. These fishing stations, as compared with those performed either at midday or at sunrise on similar locations, gave higher number of fish species and/ or with better length distribution. Figure 6 shows the fishing station allocated to each different area. These fishing station were used to characterise those echo-traces in which the visual scrutiny did no get conclusive idea about the fish species present in the echogram.

Assessment

1. Sardine

Figure 7 shows the backscattering energy attributed to sardine. Sardine was seen in thick schools in the western part (figure 8a) whilst mainly occurred in mixed layers, specially with mackerel, in the Cantabrian Sea (figure 8b). Figure 9 shows the sardine egg distribution from CUFES device. Two main areas of sardine were found. Off western coasts, most of the sardine were juveniles whereas in the Cantabrian Sea only adults fish (>19 cm) were found. In addition, most of the fish samples gave similar length distribution off north coast and no significant differences in PDF were found when Kolmogorov-Smirnoff test was performed. Table 1 shows the main inputs and the abundance estimation for each ICES Sub-Division. Besides, table 2 shows the detailed assessment by age group and length class for each ICES Sub-Division

Zone	Area	No	Mean	õ^2	Model	v*	nugget/model	Surface	Fishing st.	PDF	No (million fish)	Biomass (tonnes)
Ixa-CN	Portugal costa	50	2430.04	30226780	1.5e+06+Sph(2.0e+07;3)	730820	4.10%	437	P04,P03	p02	6495	171767
	Portugal fuera	13	527.62	1585487	700000+Sph(860000;6)	129860.5	41.50%	110	P02	p01	284	10994
	Total	***63***	***2037.48***					***547***			***6779***	***182761***
Ixa-N	Rias Baixas	80	839.30	1006990	6.0e+05+Sph(4.0e+05;3)	13859.69	44.50%	132	P05,P06,P07	p03	644	18527
	Total	***80***	***839.30***					***132***			***644***	***18527***
VIIIc-W	Capelada	23	551.22	2827156	3e+05+Sph(2.5e+06;6)	179697.7	7.30%	156	P13,P24	p04	444	15531
	Baldaio	1	1298.00	na	na	na	41.50%	8	P16	p05	31	2674
	Total	***24***	***582.34***					***164***			***475***	***18206***
VIIIc-Ew	Galicia-Asturias	121	91.20	269535.2	5.0E+04+Sph(2.2E+05;5	2821.504	14.60%	966	P20, P21, P23, P25	p06	254	23255
	Asturias Costa	57	98.45	102099.3	5.0+e04+Sph(5.0+e04;4)	2231.423	39.30%	472	P28,P35	p07	151	11457
	Asturias Oceáno	52	55.63	4314.67	2300+Sph(2000;5)	105.35	42.00%	416	P29,P31,P32	p08	65	6163
	Cantabria	13	15.15	310.47	120+Sph(200;7)	22.47	41.10%	100	P29,P31,P32	p08	4	406
	Total	***243***	***81.22***					***1954***			***475***	***41282***
VIIIc-Ee	Bilbao	30	168.41	8.64E+04	2.0e+04+Sph(6.6e+04;7)	3079.84	21.60%	233	P45,P44	p09	107	10743
	Donostia	53	25.70	3054.37	2000+Sph(2100;7)	84.97	44.40%	406	P40,P39	p10	32	2652
	Total	***83***	***77.28***					***639***			***139***	***13394***
	Total IXa	***143***	***1367.17***					***679***			***7423***	***201288***
	Total VIIIc	***350***	***114.65***					***2757***			***1089***	***72881***
	Total Spain	***430***	***249.47***					***2888***			***1733***	***91408***

Table 1: Sardine assessment by ICES Sub-Division. No means number of data points inside each area, Mean is the mean backscattering energy, õ^2 is the variance, the fitted Model from the empirical variogram when available and its associate variance, the surface expressed in square nmi, the fishing stations and the PDF used to characterise the abundance, which is expressed in both number of fish and biomass.

In general egg distribution match quite well with the adult distribution derived from the acoustic. Only in the Portuguese area and in the north west part some discrepancies were detected. In the case of Portugal, since most of the fish seen in coastal waters were immature, no eggs were expected to be found. In the north west part, close to Finisterre Cape, the differences could be explained by the bad weather conditions found when this area was covered. In such conditions, sardine uses to remain very close to the coast, in shallower waters, out of the vessel range.

Table 2 and figure 10 show the result obtained by age group and ICES Sub-Division. In the Spanish area, two area were distinguished. The western part where most of the fish belonged age group 1 and the Cantabrian Sea, where most of the fish were older than 2. The oldest fish were found at the inner part of the Bay of Biscay. Contrary to the situation seen in the previous years, close the French border sardine density was scarce, even in the South of France. The bulk of the distribution in this area was found in the middle part.

Total sardine abundance was estimated to be 1733 million fish corresponding to 91 408 tonnes. Last year, 96 thousand tonnes were estimated, but they corresponded to 1312 million fish. The difference in number was due to the important increase of younger fish occurred in the western part (IXa-North and VIIIc-West). In these areas age group 1 represented 97% and 71% of the total fish respectively. Whereas in 2000 age group 0 in VIIIc-West only represented 10% of the total fish caught in this area (48% in IXa-North), in 2001 this cohort became very important. In addition, off North Portugal this age group was very abundant (96% of a total of 178 thousand tonnes corresponding to 6 589 million fish –97% of the total-).

In spite in the Cantabrian Sea the biomass decreased from 2000 from 94 thousand tonnes to 73 thousand tonnes (1277 to 1089 million fish), the distribution area notably increased from 1545 square nmi to 2757 square nmi whilst in IXa-N remained almost similar. During the 2001 acoustic survey, sardine was observed throughout the whole continental shelf, and reached the slope. This kind of distribution agreed with the patern observed in the earlier nineties.

2. <u>Anchovy</u>

As in the case of sardine, both egg and adult distribution derived from CUFES and acoustic respectively were similar (figures 11 and 12). The bulk of the anchovy distribution occurred in France. Nevertheless some schools were seen near Cape Peñas and in Euskadi (Central part of VIIIc-Ew and VIIIc-Ee). Table 3 summarises the acoustic assessment for this fish specie.

Zone	Area	No	Mean	õ^2	Model	v*	nugget/model	Surface	Fishing st.	No (million fish)	Biomass (tonnes)
VIIIb-	Francia	24	115.63	29538.85	12000+Sph(17500;6)	1911.956	26.20%	223	P50	118	4831
	Total	***24***	***115.63***					***223.10***		***118***	***4831***
VIIIc	Machichaco	12	1.00	0.73	Sph(0.95;3.25)	0.119	0.00%	102	P45	1	18
	Cantabria	7	131.91	6669.142	na	953.06	100.00%	66	P40	49	1436
	Peñas	9	232.00	21427.75	5000+Sph(19000;6)	3328.59	16.70%	54	P28	69	2090
	Total	***28***	***107.98***					***222***		***118***	***3544***

Table 3: Acoustic assessment of anchovy during PELACUS 0401 survey (see table 1 for further explanations)

In spite only the southernmost part of the distribution area of this fish specie was covered, the relative high abundance found suggests an important presence of this fish specie around the French waters.

3. <u>Horse mackerel</u>

Contrary to sardine, horse mackerel became more and more scarce as shown in figure 13. The assessment for this fish specie is shown below in table 4

Zone	Area	No	Mean	õ^2	Model	v*	nugget/model	Surface	Fishing st.	PDF	No (million fish)	Biomass (tonnes)
Ixa-CN	Portugal	12	452.75	242876.9	Sph(242900;2.5)	27452	0.00%	98.48	P02	P02	44	5355
	Total	***12***	***452.75***					***98.48***			***44***	***5355***
Ixa-N	Rias Baixas	17	21.47	1454.89	700+Sph(760;6)	107.93	38.20%	147.81	P09, P10, P11, P12	ST01	2	437
	Total	***17***	***21.47***					***147.81***			***2***	***437***
VIIIc-W	Artabro	38	20.97	1351.918	600+Sph(1000;4.5)	61.832	25.50%	340.88	P09, P10, P11, P12	ST01	5	985
	Capelada	41	46.95	9160.298	5000+Sph(4500;4.5)	320.225	38.10%	322.22	P13, P14	ST02	12	1951
	Ortegal-off	16	40.88	1258.12	800+Sph(200;9)	92.69	53.90%	153.21	P17	P17	2	1035
	Ortegal Coast	36	28.06	1113.483	200+Sph(800;9)	21.57	25.80%	286.48	P20	P20	6	1070
	Total	***131***	***33.48***					***1102.79***			***25***	***5041***
VIIIc-Ew	Cantabria	179	136.13	55445.53	30000+Sph(28000;5)	14984.99	1.10%	1485.83	P25, P27, P36, P37	ST03	155	26443
	Total	***179***	***136.13***					***1485.83***			***155***	***26443***
VIIIc-Ee	Euskadi-Off	51	73.12	9015.55	3000+Sph(10000;6)	334.16	17.60%	400.52	P39, P40, P41, P42	ST04	25	3703
	Euskadi-Costa	10	127.20	10346.62	na		100.00%	87.95	P43	P43	8	1518
	Total	***61***	***81.99***					***488.47***			***32***	***5221***
VIIIb	Francia	17	108.76	22734.69	3000+Sph(20000;6)	2342.236	7.50%	172.25	P49	P49	16	2375
	Total	***17***	***108.76***					***172.25***			***16***	***2375***
	Total IXa	***29***	***200***					***246.29***			***47***	***5792***
	Total VIIIc	***371***	***81.38***					***3077.09***			***213***	***36704***
	Total VIIIb	***17***	***109***					***172***			***16***	***2375***
	Total Spain	***388***	***87.94***					***3224.90***			***215***	***37142***
	Total Portugal	***12***	***453***					***98***			***44***	***5355***
	Total France	***17***	***109***					***172***			***16***	***2375***

Table 4: Acoustic assessment of horse mackerel during PELACUS 0401 survey (see table 1 for further explanations)

Most of the horse mackerel seen had 27 cm as a mean length. Only near Cape Ortegal bigger fish were observed. In the Spanish area only 37 thousand tonnes were estimated whilst in 1999 up to 93 thousand tonnes were estimated. As shown in figure 14 the difference between both years was the lack of adult fish (>30 cm) occurred in 2001.

4. <u>Mackerel</u>

Mackerel is the most important fish pelagic fish specie found in spring in the Spanish waters (figure 15). During the 2001 survey, no significant differences in length distributions obtained in the fishing station were found along the Cantabrial Sea. Only in the western part of the distribution area (VIIIc-West) and a small area located close to Matxitxaco Cape gave different length distribution in which the number of juvenile fish were lower or they were absent. Table 5 summarises the assessment for this fish specie:

Zone	Area	No	Mean	õ^2	Model	v*	nugget/model	Surface	PDF	No (million fish)	Biomass (tonnes)
Ixa-N	Rias Baixas										
	Total	***0***	***0.00***					***0***		***0***	***0***
VIIIc-W	Fisterra	29	14.28	575.564	240+Sph(375;8)	22.78	36.30%	253	P10	35	11992
	Fondón	14	52.71	2507.45	240+Sph(2300;6)	328.62	5.20%	115	P11	49	21861
	Total	***43***	***26.79***					***368***		***84***	***33854***
VIIIc-Ew	Cantabria	417	24.40	2733.52	1000+Sph(1733;8)	1553.49	0.20%	3250	Pst01	699	275265
	Total	***417***	***24.4***					***3249.97***		***699***	***275265***
VIIIc-Ee	Euskadi-W	61	28.39	2943.58	Sph(3000;5.5)	74.47	0.00%	459	Pst02	136	41857
	Euskadi-E	24	32.08	3096.51	Sph(3000;5.5)	180.77	0.00%	190	Pst01	121	47549
	Total	***85***	***29.43***					***649***		***257***	***89406***
VIIIb	Francia	40	25.95	638.56	340+Sph(300;8)	23.44	36.30%	427	Pst01	98	38463
	Total	***40***	***25.95***					***426.92***		***98***	***38463***
	Total IXa	***0***	***0***					***0***		***1039***	***398525***
	Total VIIIc	***545***	***24.12***					***4267***			
										1039	***398525***
	Total Spain	***545***	***24.12***					***4267***		***1039***	***398525***

Table 5: Acoustic assessment of mackerel during PELACUS 0401 survey (see table 1 for further explanations)

A total of 399 thousand tonnes corresponding to 1039 million fish were estimated in VIIIc ICES Division. Almost no mackerel was observed in IXa-N nor IXa-CN. In comparison with the previous year, the number juvenile fish estimated in 2001 was lower than that observed last year. During 2001 most of the fish found (90%) were higher than 33 cm (figure 16).

5. <u>Others</u>

Chub mackerel (Scomber japonicus) and white horse mackerel (Trachurus mediterraneus) were important in the coastal waters of the easternmost part of the Cantabrian Sea. Blue whiting, which was the most important fish species of this area during the earlier nineties, was very scarce and it was seen only close to the slope at certain locations in VIIIc-W, and the central part of VIIIc-E.

CONCLUSIONS

1. Weather conditions were unfavourable during the first part of the survey. In spite the predominance of SW wind component, the Poleward called Navidad was not observed, at least from the TS-diagram obtained during the survey. Therefore, oceanographic conditions found during the survey was the typical in spring, with warmer water in the south part (but with not higher salinity), presence of haline fronts close to the mouth of rivers and upwelling events in the Cantabrian forced by the change of the wind direction from SW to NE occurred during the second part of the survey.
2. Sardine distribution area was wider than that observed in 2000. In addition the number of fish estimated was higher than that estimated during 2001. Major changes occurred in IXa-N and VIIIc-W where most of the fish seen belonged to age group 1. The same situation was found in Portugal.

3. Given the low number of younger fish caught during 2000 in VIIIc-W, most of the younger fish found in this area and even in IXa-N should be born in the Portuguese waters, progressing then northward.
4. Age structure found in 2001, with younger fish mainly located in Atlantic waters and and age gradient pattern through the inner part of the Bay of Biscay where the oldest fish are predominant, reflects the “normal age structure” found in the earlier nineties and eighties.
5. The sardine estimated in IXa-N is similar to that estimated during the earlier nineties. In addition, in spite the number of sardine detected in VIIIc is still lower as compared with that observed at the beginning of nineties, the distribution area was higher than that observed during the late nineties and similar to that observed in the earlier nineties.
6. In order to achieve similar abundance estimates as observed in the late eighties, the sardine density, specially in the Cantabrian, should increase.
7. Contrary to previous years, in the inner part of the Bay of Biscay and in the southern part of the French continental shelf sardine was scarce.
8. On account the results of this survey, 2000 year class of sardine seems to be good.
9. The bulk of the anchovy distribution in spring occurs in French waters. Nevertheless, some schools were seen in the Spanish waters, suggesting an important presence of this fish specie off France.
10. The Horse mackerel abundance estimates is decreasing, which could be explained by the lack of adult fish (>30 cm) in the surveyed area. As the survey did no progress further than 500 m depth as average, the adult fish, if available, could be not accessible.
11. The number of adult mackerel estimated in the Spanish area remain quite stable. Nevertheless, no signal of a good strength of the 2000 year class was observed and, therefore the total biomass estimated in 2001 was lower than that estimated in 2000.
12. Blue whiting has almost disappear from the surveyed area. As in the case of the adult horse mackerel, if this fish specie is now restricted to deeper water, it could be not accessible, and therefore, any conclusion nor abundance estimation should be postulated for this fish specie.

BIOMASS (tonnes). ZONE: VIIIc-Ee

					AGE GROUPS							
Length	1	2	3	4	5	6	7	8	9	10	Total	No fish
11												
11.5												
12												
12.5												
13												
13.5												
14												
14.5												
15												
15.5												
16												
16.5												
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17.5												
18												
18.5		5.95	0.85								6.80	0
19		4.93	2.47								7.40	0
19.5		25.03	63.98	11.13	5.56						105.70	2
20		11.73	72.72	39.88	18.77						143.10	2
20.5		17.22	150.63	133.42	34.43	8.61					344.30	5
21		6.75	209.34	229.60	108.05	20.26	6.75	6.75			587.50	8
21.5		34.45	149.28	424.88	333.01	114.83	34.45				1090.90	13
22		24.09	264.98	602.24	770.86	313.16	48.18	24.09			2047.60	23
22.5			139.93	454.79	979.54	384.82	209.90	104.95	69.97		2343.90	25
23			58.63	469.02	820.78	527.64	703.53	117.25	58.63	58.63	2814.10	27
23.5				142.84	714.19	428.51	285.68	428.51	285.68		2285.40	21
24				101.24	404.98	202.49	101.24	101.24			911.20	8
24.5					40.03	80.06		40.03	80.06	40.03	280.20	2
25					44.97	44.97		44.97			134.90	1
25.5					71.10	71.10		71.10			213.30	1
26					25.90	25.90		25.90			77.70	0
Total		130	1113	2609	4372	2222	1390	965	494	99	13394	139
%		0.97	8.31	19.48	32.64	16.59	10.38	7.20	3.69	0.74		
M. weight		70.59	79.24	89.11	97.72	101.73	102.43	110.75	108.91	110.74	95.75	
No Fish		2	14	29	44	22	14	9	5	1	139	
%		1.32	10.06	21.00	32.07	15.64	9.77	6.23	3.27	0.64		
M. length		20.75	21.49	22.27	22.90	23.18	23.23	23.79	23.67	23.79	22.76	
s.d.		1.09	0.95	0.91	0.93	0.94	0.54	0.88	0.57	0.72	1.10	

Table 2a: Acoustic assessment of sardine by age group and length class. Area: VIIIc-Ee

BIOMASS (tonnes). ZONE: VIIIc-Ew

Length	AGE GROUPS 1	2	3	4	5	6	7	8	9	10	Total	No fish
11												
11.5												
12												
12.5												
13												
13.5												
14												
14.5												
15												
15.5												
16	20.10										20.10	1
16.5	88.10										88.10	3
17	96.80	96.80									193.60	5
17.5	182.20	182.20									364.40	9
18	121.33	24.27									145.60	3
18.5	25.56	102.24									127.80	3
19	76.80	230.40									307.20	6
19.5		668.50									668.50	11
20		1500.30									1500.30	23
20.5		2723.60									2723.60	39
21		2660.72	665.18								3325.90	44
21.5		657.63	4384.23	438.42	219.21						5699.50	69
22		144.97	3334.22	1884.56	1014.76						6378.50	72
22.5		206.03	3090.42	2575.35	515.07	206.03					6592.90	69
23			2122.02	2893.66	964.55	192.91		96.46			6269.60	61
23.5		146.10	535.69	1509.66	1071.37	243.49	97.40				3603.70	33
24		26.76	294.41	615.58	802.94	321.17	26.76	26.76			2114.40	18
24.5			50.19	138.03	263.51	87.84	50.19	25.10	12.55		627.40	5
25			10.89	87.14	141.61	87.14	98.04	21.79	10.89	10.89	468.40	3
25.5				3.88	19.38	11.63	7.75	11.63	7.75		62.00	0
26												
Total	611	9371	14487	10146	5012	1150	280	182	31	11	41282	475
%	1.48	22.70	35.09	24.58	12.14	2.79	0.68	0.44	0.08	0.03		
M. weight	41.78	69.05	90.13	98.86	102.48	110.33	122.02	112.56	133.12	134.82	85.47	
No Fish	15	134	160	102	49	10	2	2	0	0	475	
%	3.06	28.32	33.75	21.55	10.25	2.19	0.48	0.34	0.05	0.02		
M. length	17.69	20.61	22.34	22.98	23.23	23.76	24.50	23.90	25.15	25.25	21.99	
s.d.	0.78	1.05	0.68	0.67	0.88	0.75	0.67	0.84	0.39		1.52	

Table 2b: Cont'd. Area VIIIc-Ew

BIOMASS (tonnes). ZONE: VIIIc-W												
	AGE GROUPS											
Length	1	2	3	4	5	6	7	8	9	10	Total	No fish
11												
11.5												
12												
12.5												
13												
13.5												
14	59.90										59.90	3
14.5	67.10										67.10	3
15	449.30										449.30	18
15.5	1998.60										1998.60	70
16	3804.81	1087.09									4891.90	155
16.5	2209.74	339.96									2549.70	73
17	1298.40	162.30									1460.70	38
17.5	288.60	1443.00									1731.60	41
18	480.98	60.12									541.10	12
18.5	381.90	509.20									891.10	18
19		488.10									488.10	9
19.5	8.09	56.61									64.70	1
20		161.37	80.69	40.34							282.40	4
20.5	5.24	26.18	120.41	20.94	5.24						178.00	3
21	10.06	10.06	301.93	201.29	70.45						593.80	8
21.5		9.89	242.39	153.35	39.57	9.89					455.10	6
22		4.53	122.43	194.98	68.02	13.60		4.53			408.10	5
22.5		19.02	69.73	266.23	158.47	38.03	19.02				570.50	6
23		3.21	38.57	83.57	128.57	48.21	9.64	3.21			315.00	3
23.5			10.27	28.24	56.48	17.97	10.27	7.70	2.57		133.50	1
24			0.96	7.68	14.39	8.64	8.64	2.88	0.96	0.96	45.10	0
24.5				1.18	5.88	3.53	2.35	4.71	2.35		20.00	0
25				1.17	4.67	2.33	1.17	1.17			10.50	0
25.5												
26												
Total	11063	4381	987	999	552	142	51	24	6	1	18206	475
%	60.76	24.06	5.42	5.49	3.03	0.78	0.28	0.13	0.03	0.01		
M. weight	32.62	40.22	79.15	86.09	93.54	99.69	104.71	108.16	117.27	118.02	36.85	
No Fish	336	107	12	12	6	1	0	0	0	0	475	
%	70.74	22.53	2.61	2.43	1.23	0.30	0.10	0.05	0.01	0.00		
M. length	16.41	17.49	21.48	22.04	22.60	23.04	23.38	23.62	24.20	24.25	17.03	
s.d.	0.78	1.16	0.75	0.84	0.87	0.70	0.66	0.91	0.46		1.67	

Table 2c: Cont'd. Area: VIIIc-W

BIOMASS (tonnes). ZONE: IXa-N												
	AGE GROUPS											
Length	1	2	3	4	5	6	7	8	9	10	Total	No fish
11	7.90										7.90	1
11.5	44.80										44.80	4
12	51.30										51.30	4
12.5	93.40										93.40	7
13	53.00										53.00	3
13.5	331.00										331.00	18
14	598.10										598.10	29
14.5	988.00										988.00	43
15	2419.90										2419.90	94
15.5	3873.45	121.05									3994.50	140
16	6073.60										6073.60	192
16.5	2700.64	240.06									2940.70	84
17	529.07	186.73									715.80	19
17.5	64.50	150.50									215.00	5
18												
18.5												
19												
19.5												
20												
20.5												
21												
21.5												
22												
22.5												
23												
23.5												
24												
24.5												
25												
25.5												
26												
Total	17829	698									18527	644
%	96.23	3.77										
M. weight	28.15	35.51									28.35	
No Fish	625	20									644	
%	96.97	3.03										
M. length	15.69	16.84									15.73	
s.d.	0.96	0.67									0.97	

Table 2d: Cont'd. Area IXa-N

BIOMASS (tonnes). ZONE: IXa-CN

Length	1	2	3	4	5	6	7	8	9	10	Total	No fish
	AGE GROUPS											
11												
11.5												
12												
12.5												
13												
13.5	591.50										591.50	32
14	10272.70										10272.70	501
14.5	32482.60										32482.60	1415
15	43522.30										43522.30	1699
15.5	56551.40										56551.40	1985
16	22428.40										22428.40	710
16.5	6918.56	1729.64									8648.20	248
17	1505.02	1881.28									3386.30	88
17.5	276.23	1933.58									2209.80	52
18	81.20	324.80									406.00	9
18.5		666.75	222.25								889.00	18
19		322.70									322.70	6
19.5												
20				190.60							190.60	3
20.5			206.55	206.55							413.10	6
21			223.40			223.40					446.80	6
21.5												
22												
22.5												
23												
23.5												
24												
24.5												
25												
25.5												
26												
Total	174630	6859	652	397		223					182761	6779
%	95.55	3.75	0.36	0.22		0.12						
M. weight	26.33	40.04	62.93	67.87		76.39					26.71	
No Fish	6589	170	10	6		3					6779	
%	97.21	2.51	0.15	0.09		0.04						
M. length	15.38	17.46	20.03	20.50		21.25					15.44	
s.d.	0.64	0.67	1.13	0.25							0.76	

Table 2e: Cont'd. Area IXa-CN

BIOMASS (tonnes). ZONE: Spain												
	AGE GROUPS											
Length	1	2	3	4	5	6	7	8	9	10	Total	No fish
11	8										7.90	1
11.5	45										44.80	4
12	51										51.30	4
12.5	93										93.40	7
13	53										53.00	3
13.5	331										331.00	18
14	658										658.00	32
14.5	1055										1055.10	46
15	2869										2869.20	112
15.5	5872	121									5993.10	210
16	9899	1087									10985.60	348
16.5	4998	580									5578.50	160
17	1924	446									2370.10	62
17.5	535	1776									2311.00	55
18	602	84									686.70	15
18.5	407	617	1								1025.70	20
19	77	723	2								802.70	15
19.5	8	750	64	11	6						838.90	14
20		1673	153	80	19						1925.80	30
20.5	5	2767	271	154	40	9					3245.90	46
21	10	2678	1176	431	178	20	7	7			4507.20	59
21.5		702	4776	1017	592	125	34				7245.50	88
22		174	3722	2682	1854	327	48	29			8834.20	99
22.5		225	3300	3296	1653	629	229	105	70		9507.30	99
23		3	2219	3446	1914	769	713	217	59	59	9398.70	91
23.5		146	546	1681	1842	690	393	436	288		6022.60	55
24		27	295	725	1222	532	137	131	1	1	3070.70	26
24.5			50	139	309	171	53	70	95	40	927.60	7
25			11	88	191	134	99	68	11	11	613.80	5
25.5				4	90	83	8	83	8		275.30	2
26					26	26		26			77.70	0
Total	29502	14580	16587	13754	9936	3515	1721	1171	531	111	91408	1733
%	32.28	15.95	18.15	15.05	10.87	3.85	1.88	1.28	0.58	0.12		
M. weight	29.82	53.37	88.52	95.76	99.78	104.26	105.10	110.97	110.09	112.67	47.22	
No Fish	976	263	187	143	99	33	16	10	5	1	1733	
%	56.30	15.17	10.76	8.25	5.71	1.93	0.94	0.60	0.28	0.06		
M. length	15.97	19.06	22.22	22.76	23.05	23.35	23.41	23.80	23.74	23.91	18.36	
s.d.	0.99	1.94	0.77	0.82	0.93	0.92	0.71	0.88	0.65	0.80	3.17	

Table 2f: Cont'd. Area: Spain.

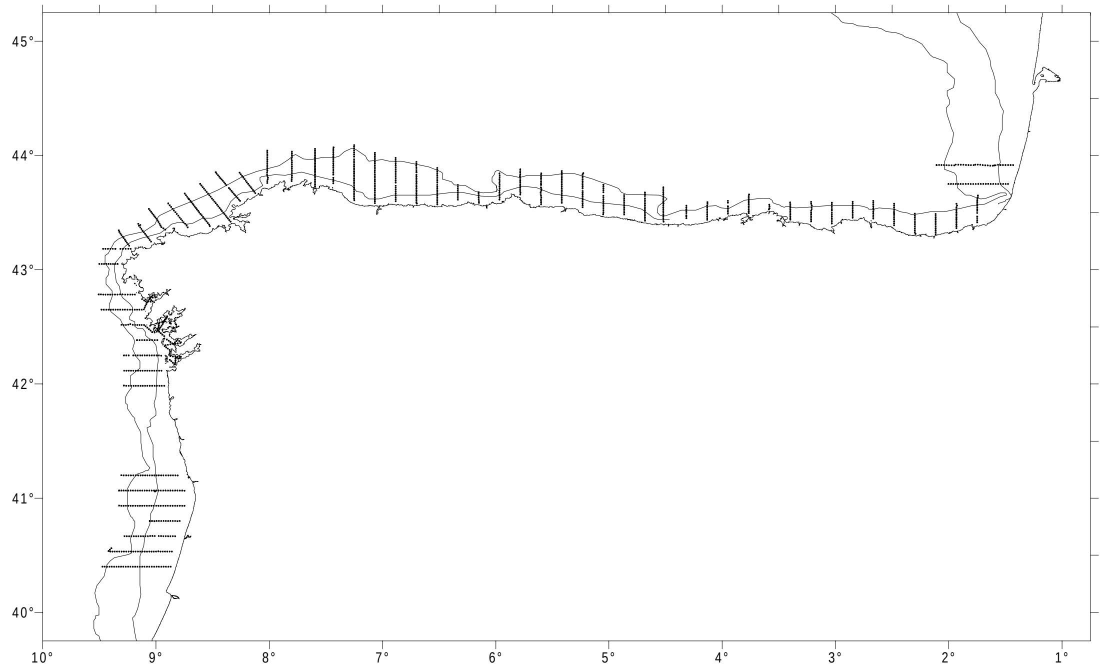


Figure 1: Survey track

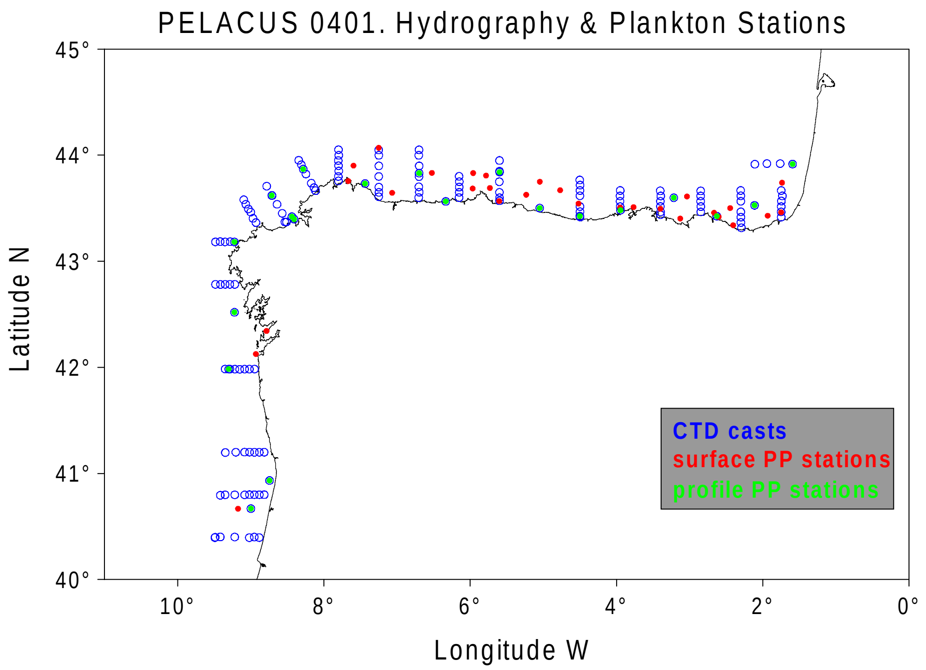


Figure 2: CTD (and plankton) stations.

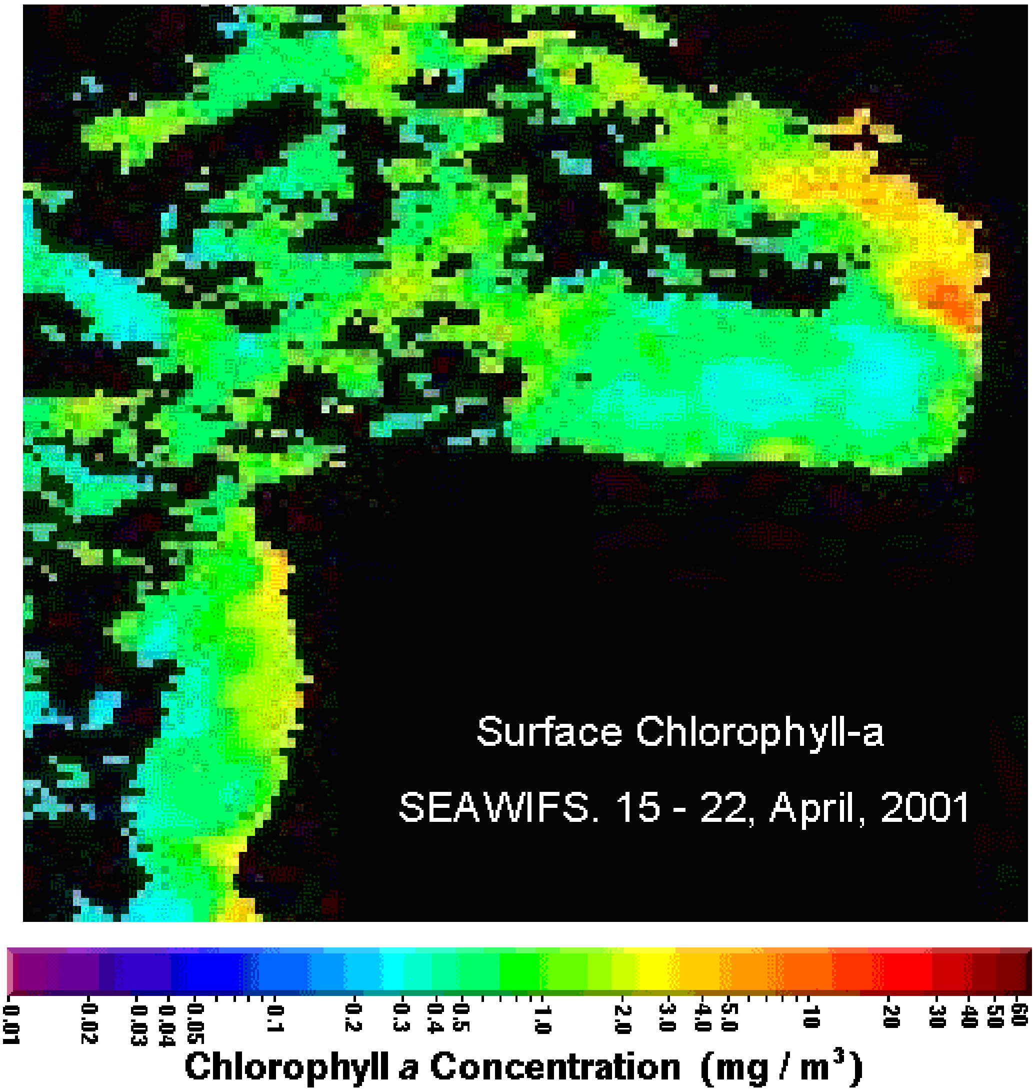

Surface Chlorophyll-a
SEAWIFS. 15 - 22, April, 2001
0.01
0.02
0.03
0.04
0.05
0.1
0.2
0.3
0.4
0.5
1.0
2.0
3.0
4.0
5.0
10
20
30
40
50
60
Chlorophyll a Concentration (mg / m³)

Figure 3

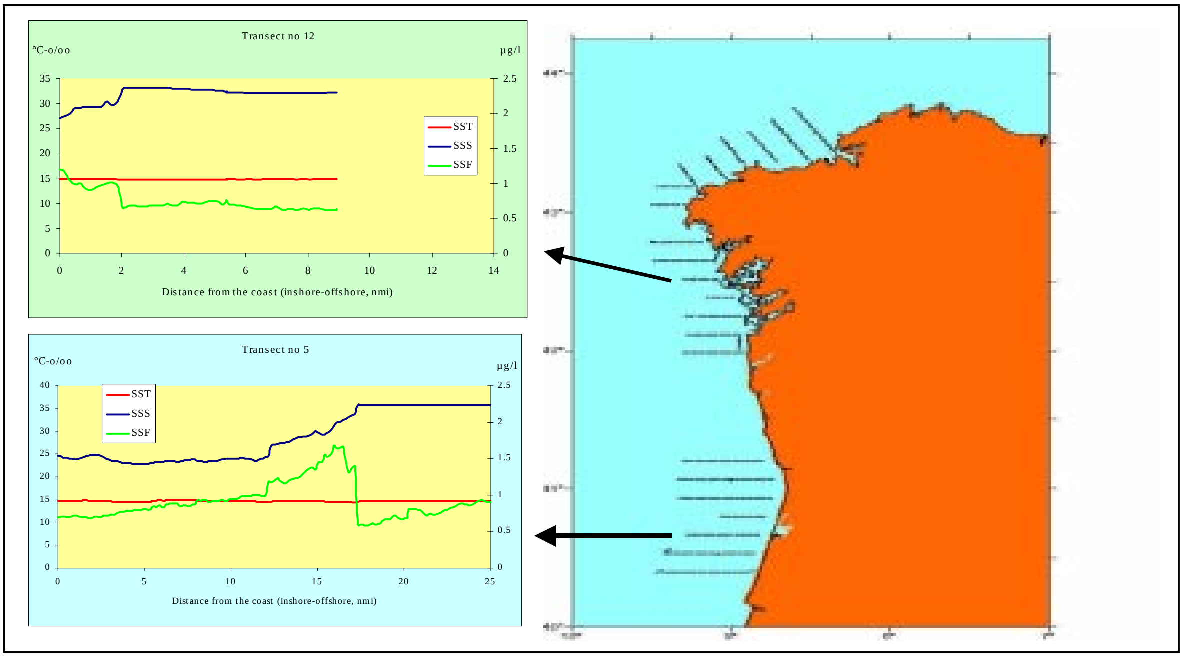


Figure 4$_{a-b}$: Surface salinity, temperature and fluormetry in two locations. Above outside the rias and below, in Aveiro.

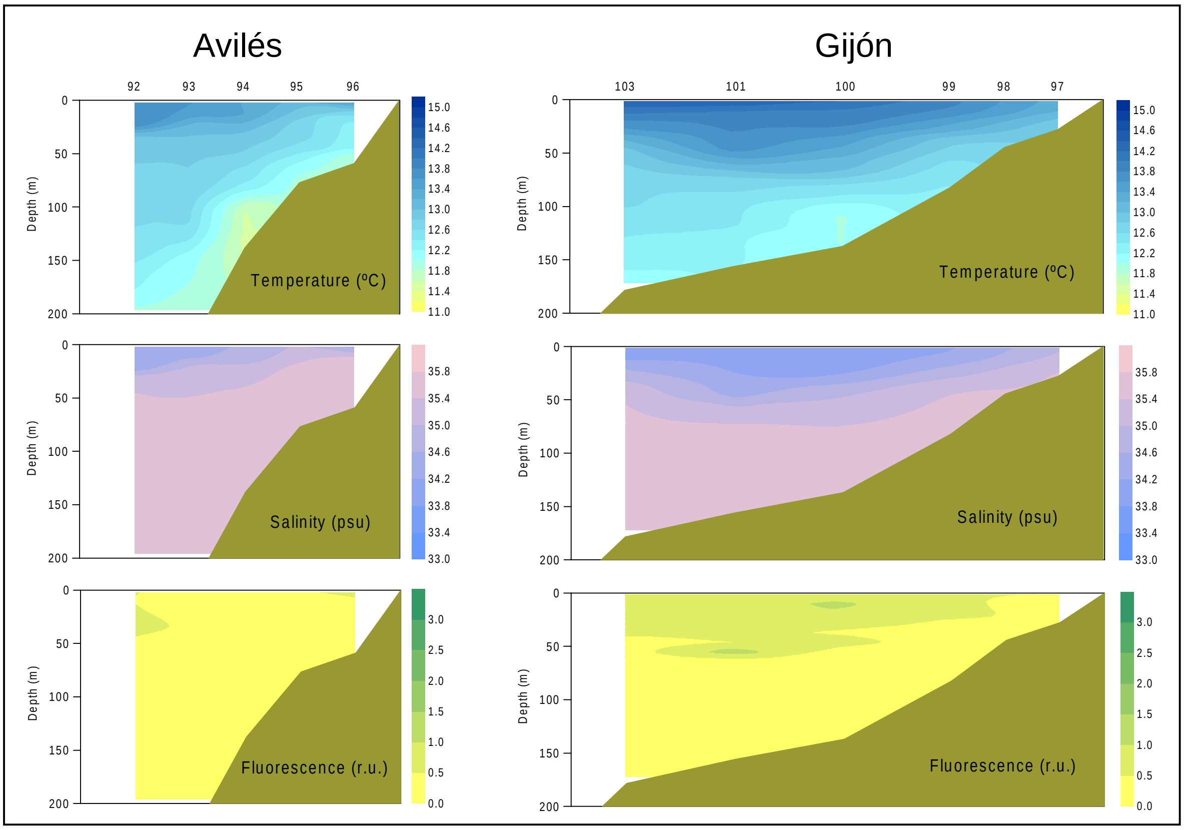


Figure 5. Coastal upwelling observed in the central part of the Cantabrian Sea

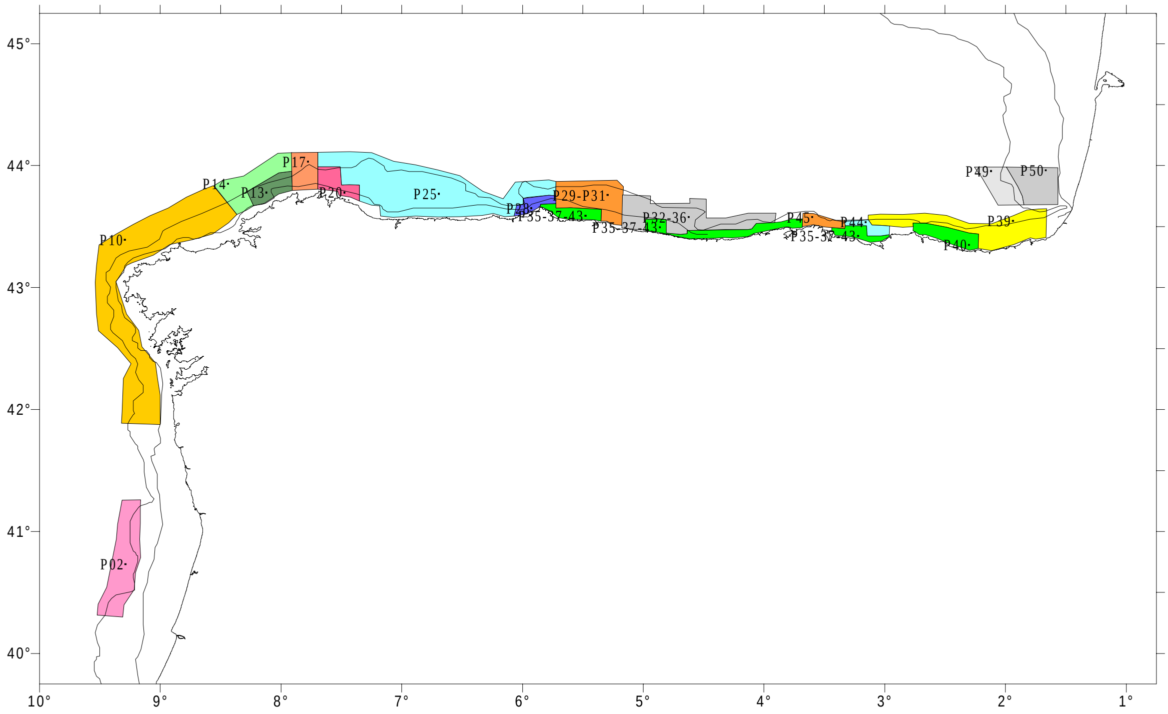


Figure 6: Number of the fishing station and area for which that fishing station was applied to split Sa energy if visual scrutiny did no achieve any conclusion on species ID.

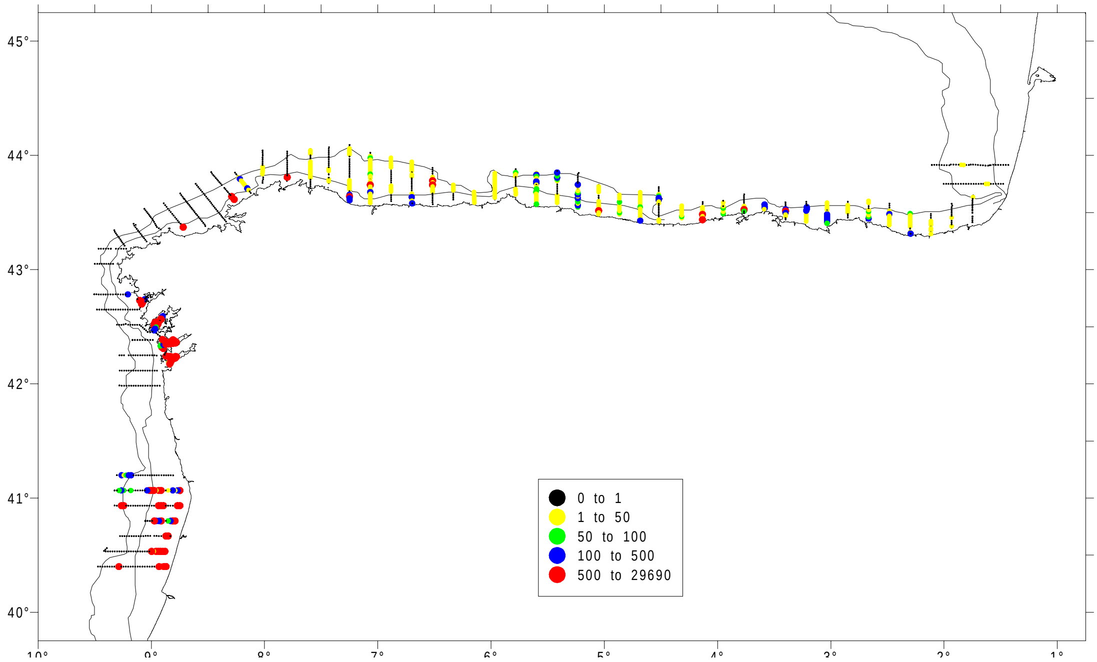


Figure 7: Sardine distribution derived from the backscattering energy.

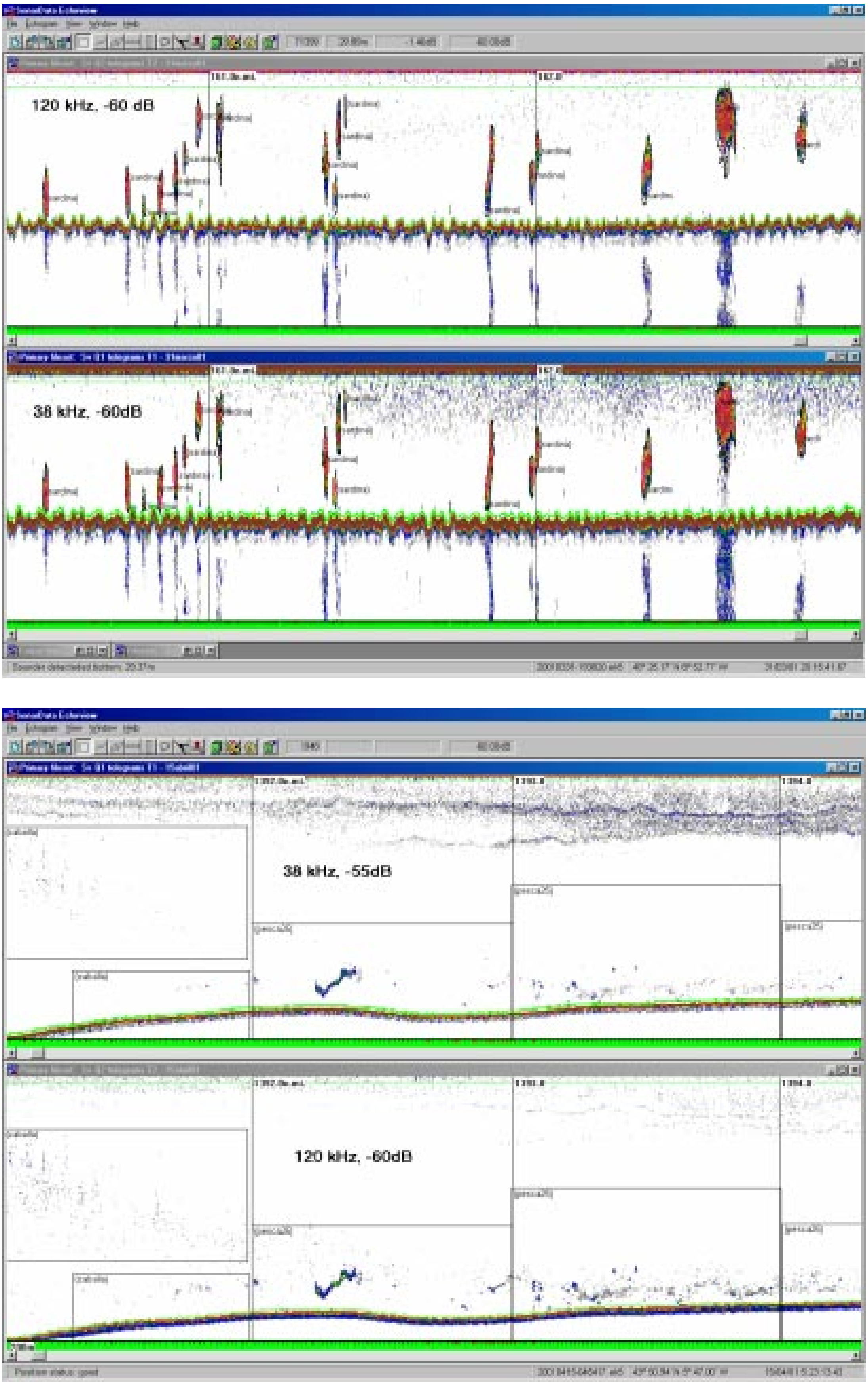


Figure 8: Echotraces of sardine Above in the Western part; below in the Cantabrian Sea

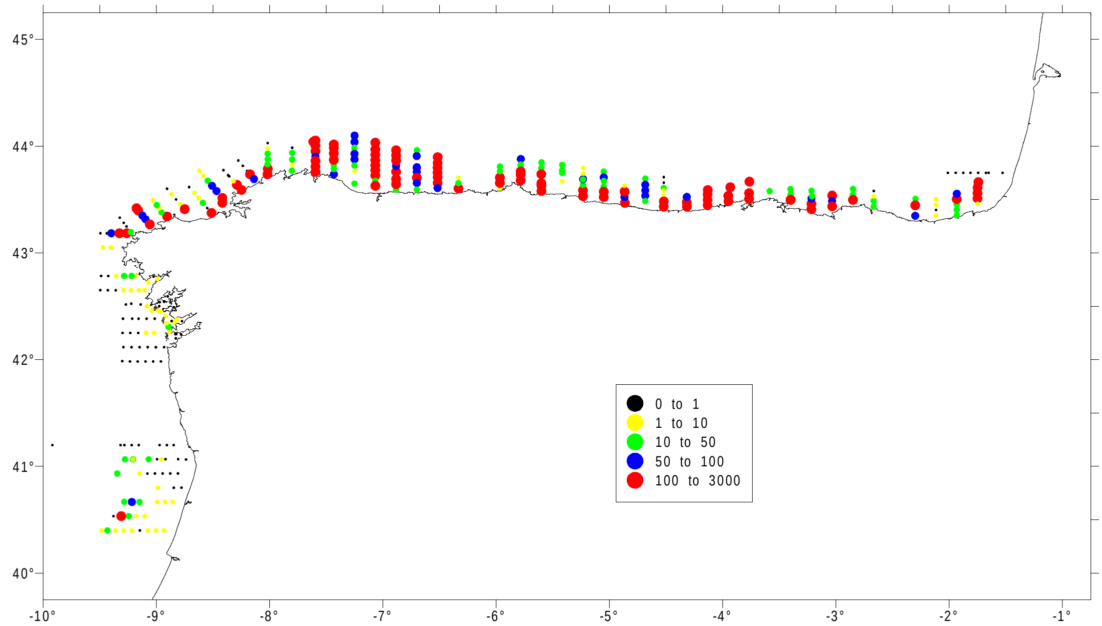


Figure 9: Sardine egg distribution from CUFES.

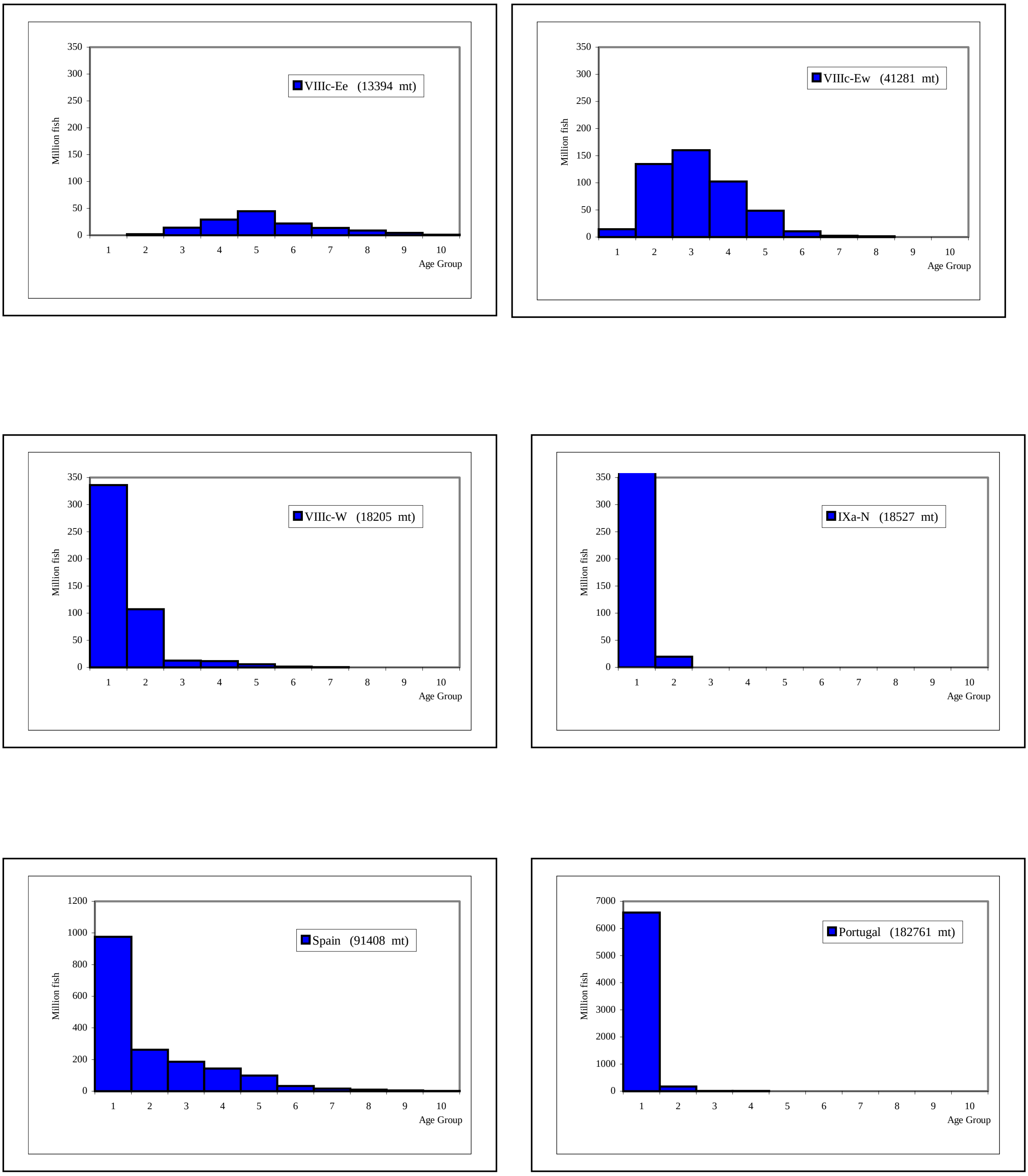


Figure 10: Abundance estimates of sardine by age group and ICES SUB-Division

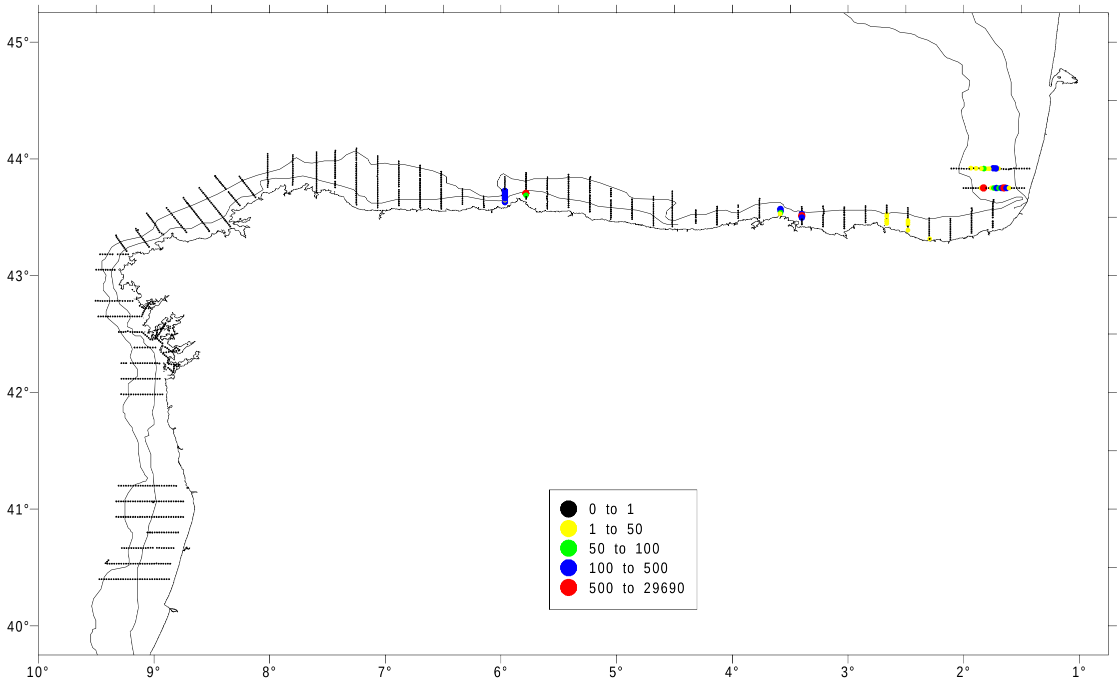


Figure 11: Anchovy distribution derived form the backscattering energy attributed to this fish specie.

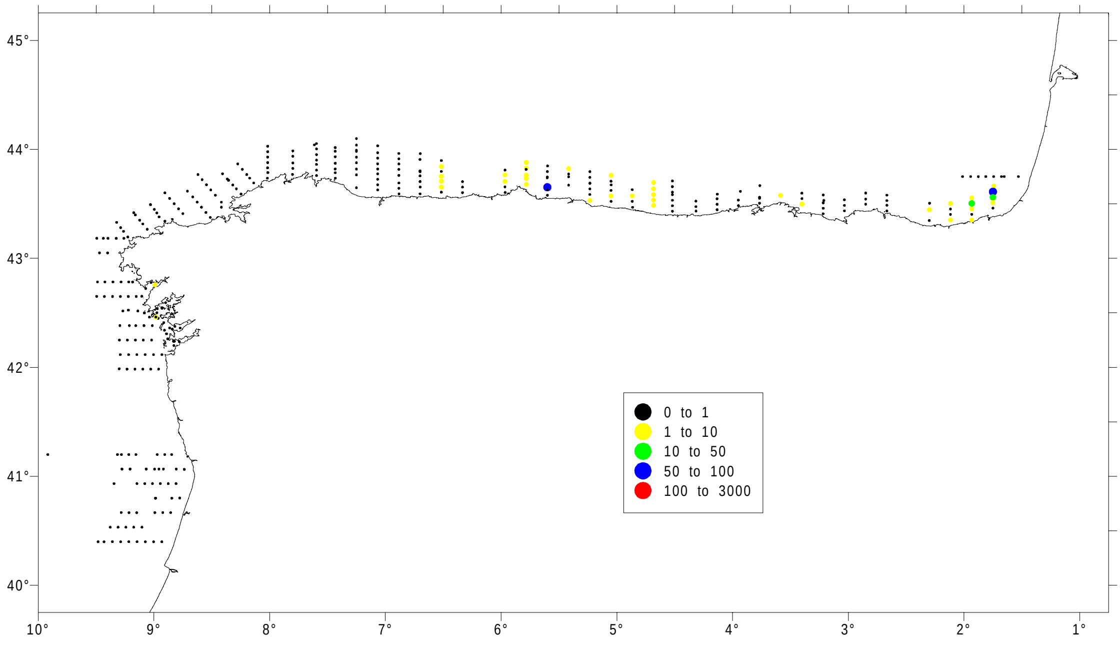
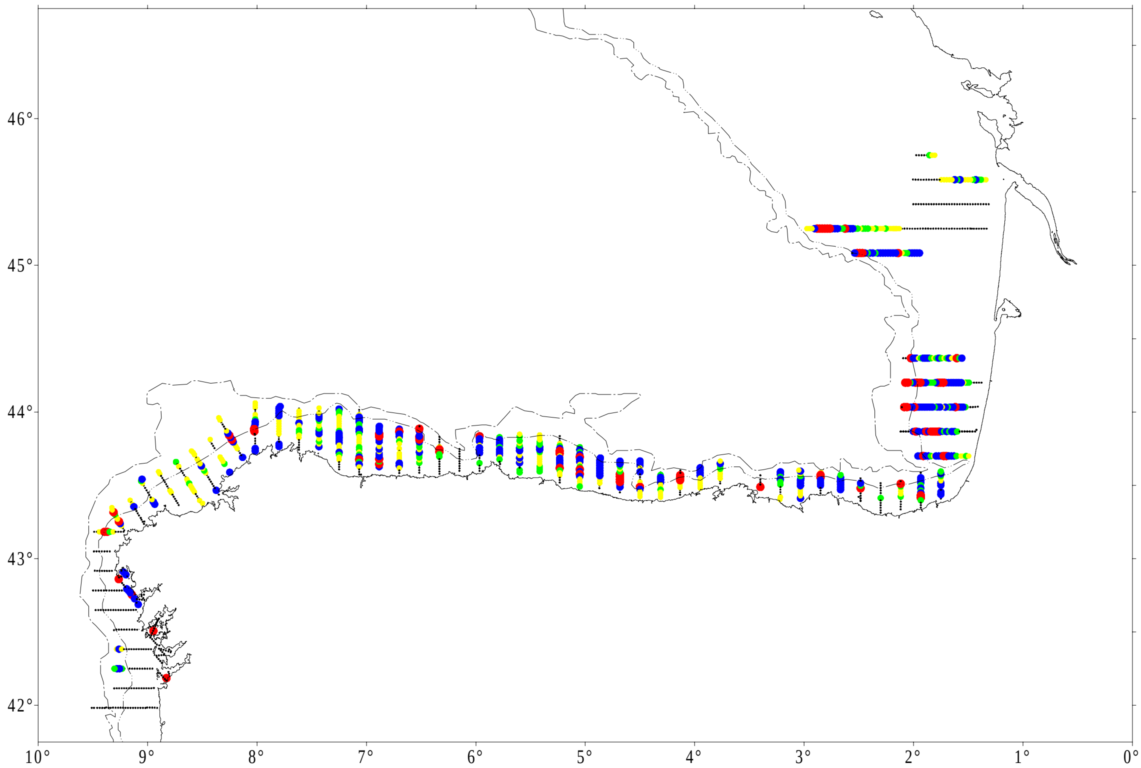


Figure 12: Anchovy egg abundance from CUFES



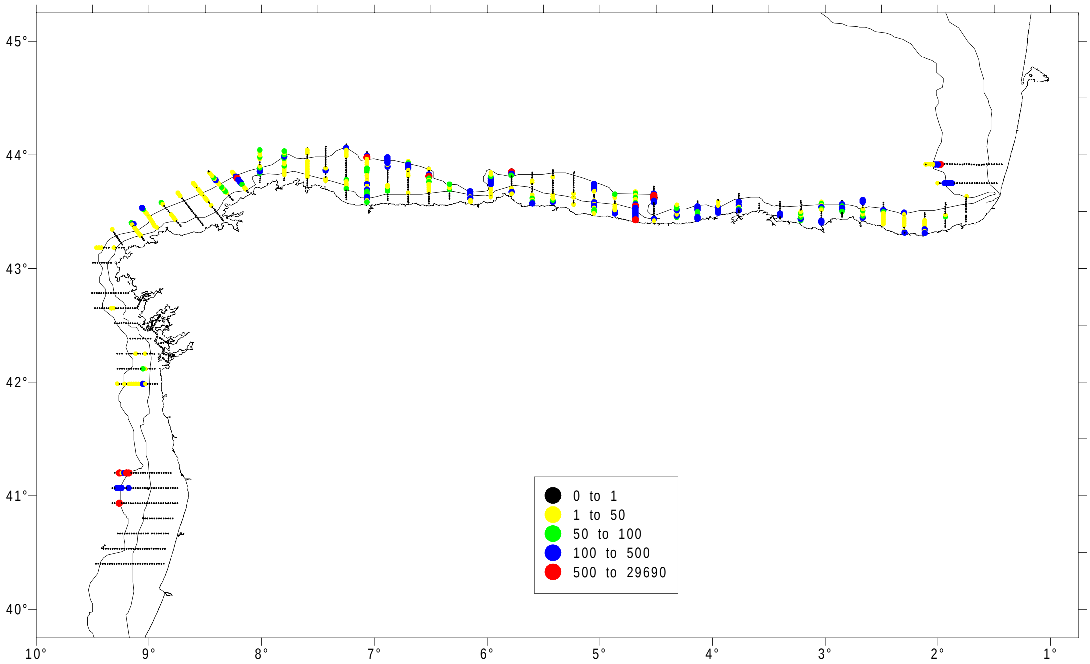


Figure 13: Horse mackerel distribution derived form the backscattering energy attributed to this fish specie. Above during 1999 acoustic survey; below, during 2001 acoustic survey.

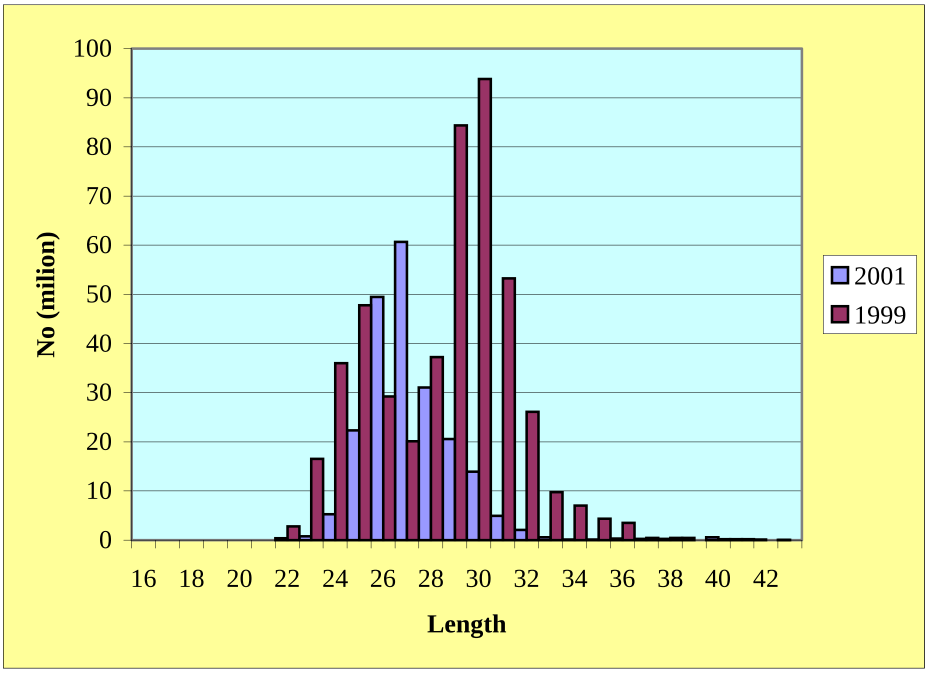


Figure 14: Horse mackerel abundance estimation by length class from 1999 and 2001.

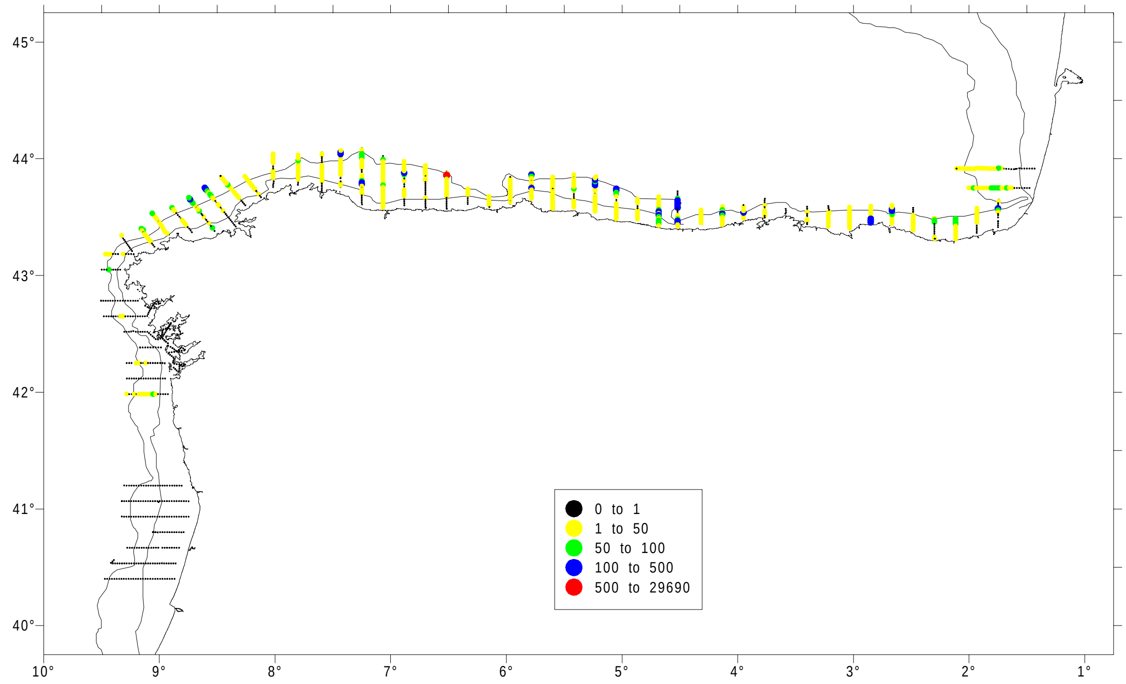


Figure 15: Mackerel distribution derived from the backscattering energy attributed to this fish specie.

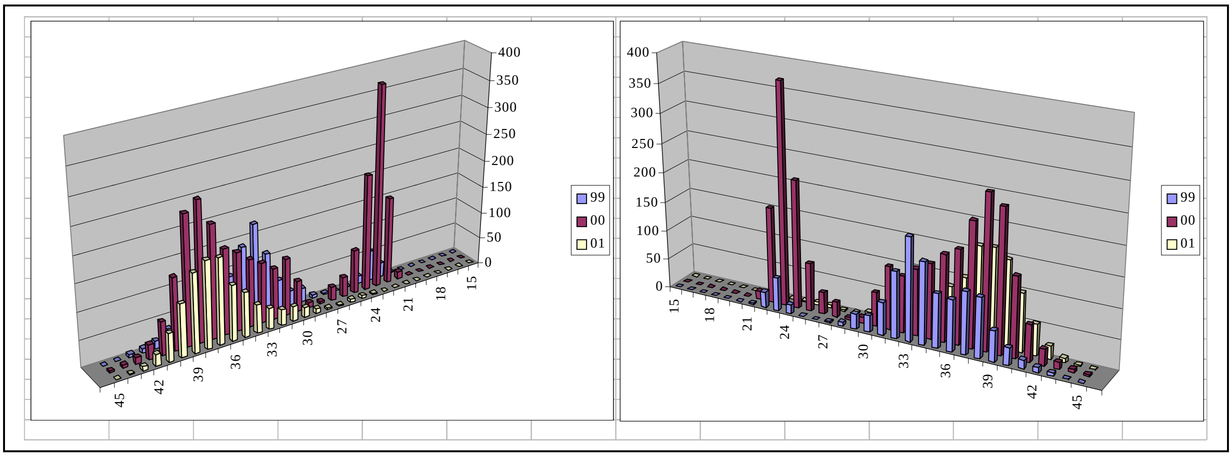


Figure 16: Mackerel abundance estimation by length class from 1999 to 2001.